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Title of the invention: MANUFACTURING METHOD OF LIGHT-EMITTING DIODE WITH IR-VISIBLE LIGHT CONVERSION FUNCTION

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Specification

Title of the Invention: MANUFACTURING MEI'HOD OF LIGHT-EMITTING DIODE WITH IR-VISIBLE LIGHT CONVERSION FUNCTION

Claim(s)

A manufacturing method of a light-emitting diode with an IR-visible light conversion function, comprising: forming a recess in the shape of truncated cone or similar shape at the center of a diode stem; mounting a pellet including a p-n junction and emitting infrared light, on the bottom of the recess; dropping a given amount of an IR-visible light conversion phosphor material into the recess to form an IR-visible light conversion phosphor layer with a given thickness around said pellet; dropping an adhesive onto the

layer; heating them to solidify and fix the IR-visible light conversion phosphor material around said pellet; and performing lens-sealing or molding.

Detailed description of the invention

The present invention relates to a manufacturing method of a light-emitting diode with an infrared-visible light conversion function comprising a pellet which includes a phosphor having an infrared-visible light conversion function phosphor and a p-n junction of a semiconductor material for emitting infrared radiation.

Light-emitting diodes with an IR-visible light conversion function that combine a pellet having a p-n junction of gallium arsenide using silicon as a donor and acceptor impurity and emitting infrared radiation with an yttrium fluoride phosphor using, e.g., ytterbium as a sensitizer and erbium as an activator, are well known. In the manufacture of such light-emitting diodes in accordance with Fig. 1, conventionally the phosphor is mixed with silicon resin or epoxy resin and applied under a microscope, by using a suitable jig, around a pellet 2 including a p-n junction and emitting infrared radiation that is mounted on the stem 1 of the diode; in this method, however, the pellet usually has a small area of 0.5 x 0.5 mm^2 on which the phosphor has to be applied with a thickness in the order of 1 mm, which operation is very delicate and time-consuming, includes a large number of process steps, and moreover the thickness of the applied phosphor is lacking in reproducibility. For this reason, there was the drawback that scattering of the output of visible light was high and the infrared light emitted from the pellet was not utilized sufficiently, so that the intensity of visible light was reduced.

It is the object of the present invention to improve a manufacturing method of a light-emitting diode having infrared-visible light conversion function having the above mentioned drawbacks, and moreover to provide a manufacturing method that is suitable for automation.

According to the present invention, a manufacturing method of a light-emitting diode with an IR-visible light conversion function is obtained, comprising: forming a recess in the shape of truncated cone or similar shape at the center of a diode stem; mounting a pellet including a p-n junction and emitting infrared light, on the bottom of the recess; dropping a given amount of an IR-visible light conversion phosphor material into the recess to form an IR-visible light conversion phosphor layer with a given thickness around said pellet; dropping an adhesive onto the layer; heating them to solidify and fix

the IR-visible light conversion phosphor material around said pellet; and performing lens-sealing or molding.

In the following, the present invention is explained in more detail by referring to the drawings.
According to the present invention, a diode stem 11 as shown in Fig. 2 is employed. At the center of the diode stem, a recess 3 in the shape of truncated cone or similar shape is formed. A pellet 6 including a p-n junction and emitting infrared light is mounted on the bottom of the recess 3 which has the truncated cone or similar shape, as shown in Fig. 2. Next, as shown in Fig. 3, an adequate amount of an IR-visible light conversion phosphor material is dropped into the recess 3 from above the stem 11 to form a phosphor layer 7 around the pellet 6. If the dropped amount of the phosphor material is constant, the thickness of the phosphor layer 7 is always constant.

Next, in order to improve the adhesion between the phosphor layer 7 and the pellet 6, as shown in Fig. 4, an adequate amount of a thermoplastic resin 5 is dropped. In this case, the thermoplastic resin 5 has a suitable viscosity and is, for example, a silicon resin or an epoxy resin. Then, the thermoplastic resin 5 and the phosphor layer 7 configured as shown in Fig. 4 are gradually heated to penetrate the thermoplastic resin 5 into the phosphor layer 7. After hardening with heating, lens-sealing or molding with an epoxy resin is performed.

In the above-described manufacturing process, the injection of the IR-visible light conversion phosphor material 7 is performed using an injector apparatus 4 such as an injector as shown in Fig. 3. Also, the dropping of the silicon resin or epoxy resin is performed using a dropping apparatus 8 such as an injector as shown in Fig. 4.. In these processes, the stem 11 is sequentially moved to the positions immediately below the injector apparatus 4 and the dropping apparatus 8. First, when the recess 3 having the truncated cone or similar shape of the stem 11 is positioned immediately below the injector apparatus 4, the injector apparatus 4 drops the phosphor material into the recess 3 to form the phosphor layer 7. Then, the stem 11 is moved to be positioned immediately below the dropping apparatus 8. The dropping apparatus 8 then drops the silicon resin or epoxy resin into the recess 3. This can achieve a fully-automated operation of phosphor coating. Consequently, operations are simplified to decrease the required process steps. In addition to this, the thickness of the phosphor layer 7 can always be controlled to be constant. This can achieve high reproducibility for the visible light output. The thus manufactured light-emitting diode having an IR-visible light conversion function can

reflect the emitted IR light with the use of the recess 3 in the shape of truncated cone or similar shape. Accordingly, the amount of IR light absorbed by the phosphor material increases, thereby increasing the output of visible light.

Brief Description of the Drawings

Fig. 1 is a schematic view showing the structure of a diode stem and an infrared light-emitting diode mounted thereon, for illustrating a conventional manufacturing method. In the drawing, reference numeral 1 denotes the diode stem, and 2 a pellet emitting infrared light and having a p-n junction.

Figs. 2, 3, and 4 are diagrams for illustrating the present invention. Fig. 2 is a schematic view showing the structure of a diode stem and an infrared light-emitting diode mounted, in which reference numeral 3 denotes a recess in the shape of truncated cone, 6 a pellet having a p-n junction and emitting infrared light, and 11 a diode stem. Fig. 3 is an explanatory view showing the process of forming an IR-visible light conversion phosphor layer, in which reference numeral 3 denotes the recess in the shape of truncated cone, 4 an apparatus for injecting a phosphor material, 6 the pellet having a p-n junction and emitting infrared light, 7 a phosphor layer, and 11 the diode stem. Fig. 4 is a view for explaining the drop of an adhesive, in which reference numeral 3 denotes the recess in the shape of truncated cone, 5 a thermoplastic resin, 6 the pellet having a p-n junction and emitting infrared light, 7 the phosphor layer, 8 a dropping apparatus for dropping the thermoplastic resin, and 11 the diode stem.